Appendix E
Generic Detailed Hydrologic Engineering Management Plan (HEMP) for a Water Control Management Study

E-1. Sample HEMP

This sample HEMP can be used as a guide for hydrologic engineering components of a water control management study. This appendix assumes that a general plan for reservoir regulation has been established, which is the result of a water conservation study (Appendix F), a flood control study, or new project construction, and that a water control plan and water control manual are to be developed. The HEMP covers the development of data collection procedures, forecasting procedures, drought detection procedures, development of reservoir regulation rule curves, and other information. Reference is made to ER 1110-2-240 and EM 1110-2-3600. Not included in this appendix are the hydrologic engineering studies needed for a dam safety plan.

E-2. Preliminary Investigations

This is a preparatory phase that includes scoping the project, deciding upon and gathering data, coordinating, etc. (Experience has shown that more than 50 percent of the study's budget can be consumed by data gathering and preparation.)

a. Do initial preparation/coordination.

(1) Identify agencies/parties with which coordination is needed--for data, operational requirements.

(2) Review existing documents.

(a) Design documents.

(b) Interagency agreements.

(c) Studies by Corps.

(d) Studies by other agencies.

(3) Visit existing project(s).

b. Obtain hydrologic data--see Appendices D and F.

c. Scope major hydrologic activities; choose models to be used.

d. Prepare detailed HEMP.

E-3. Develop Study Models

Because the water control management study is the final phase in project development, hydrologic/hydraulic models will most likely have been developed in previous phases of the project. If additional modeling studies are required, then data will have to be obtained and model calibration undertaken. See Appendices D and F. Note that the development of an operational forecast model is treated separately, below.

E-4. Develop Seasonal Flood Control Rule Curve

A seasonal guide curve--specifying the upper limit elevation for flood control throughout the year--may have been developed in earlier study phases; however, this may need review and refinement for actual regulation. Also, the object of the water management study might be to modify the existing rule curve to improve regulation or accommodate a revised policy. This analysis is one of evaluating flood potential throughout the year. If streamflow records are short, the analysis could be augmented by looking at precipitation records to ensure that an adequate sampling of runoff potential for a given calendar date is achieved.

a. Obtain historic flood data for the project site, including secondary floods that occur off-season.

(1) Obtain recorder traces from the U.S. Geological Survey.

(2) Convert traces to streamflow hydrographs.

(3) Compute volumes appropriate to flood control storage.

b. Review long-period rainfall and streamflow records in the region to augment project records. Estimate project inflow data through regional correlation techniques or, perhaps, a rainfall-runoff model.

(1) Decide on a processing technique (DSSMATH, STATS, etc.).

(2) Enter data into database.

(3) Perform calculations.

(4) Display results; verify for reasonableness.

(5) Use rainfall-runoff model if required.

(a) Obtain precipitation records.

(b) Calibrate model.

(c) Apply precipitation, compute hydrograph.

(d) Display, verify reasonableness.

c. Compute volume of water stored for each flood, given the planned flood regulation plan.

(1) Determine computational technique, e.g., spreadsheet, existing model such as the Hydrologic Engineering Center (HEC-5), etc.

(2) Prepare spreadsheet/model, check with test data.

(3) Establish regulation rules, assumptions of forecast knowledge.

(4) Perform routings using newly derived inflow data.

(5) Display results, review for reasonableness.

d. Construct seasonal flood control rule curve.

(1) Plot storage requirement as a function of date.

(2) Plot tentative envelope line representing rule curve. Incorporate limitations for rate of draft, etc.

(3) Identify outlier points, estimate probability of event. Decide whether to envelop or not.

(4) Identify impacts on other project functions and compare with rule curves used in project authorization.

(5) Decide upon final rule curve.

E-5. Develop Forecasting Model

Assess whether the project under consideration warrants a forecast model as a part of the reservoir regulation activities, and whether staffing is available to maintain and operate the model. If that assessment is affirmative, then a model is needed for future operational application. It is likely that an existing study model can be used as a basis for development of the forecasting model. Assess whether forecasting is also to be done for conservation operation purposes, as well as flood control. If so, a continuous model capable of forecasting low-flow conditions might be the appropriate choice.

a. Select computer program (HEC-1F, SSARR, etc.) to be used. Factors to be considered are: size and complexity of basin (reservoir projects, diversions, etc.); type of runoff regime (rain, snow, flash flood potential); and applications required (flood operations, low-flow forecasting).

(1) Review information and models; consult as necessary with users and experts.

(2) Obtain models, run tests.

(3) Evaluate resources needed for real-time application (computers, people, funds).

(4) Select model.

b. Review historic and real-time data availability and obtain hydrometeorological data pertinent to forecasting and project operation. Process data for input to forecast model.

(1) Set up forecast database (likely (HEC-Data Storage System)).

(2) Consider data types needed (precipitation, temperature, streamflow, etc.).

(3) Examine period of record and select flood events that should be used in calibrations.

(4) Obtain data and download to database.

(5) Perform data screening/data display to verify data.

c. Choose likely hydromet station candidates for real-time application.

(1) Review performance of existing real-time telemetry.

(2) Examine feasibility of providing future automation.

(3) Determine relative merit of stations as indices to forecasting runoff.

(a) Compute correlations of precipitation versus runoff.

(b) Examine locations so that a range of elevation and spacial coverage is obtained.

(4) Select likely best candidates.

d. Configure model for operational forecast application. This might be an expansion or a simplification of the study model, if available.

(1) Develop model characteristics.

(a) Project characteristics (storage tables, outflow limits, etc.).

(b) Routing reaches (initial estimates of routing factors).

(c) Basin configuration (combining points, diversions, balances, etc.).

(2) Estimate initial hydromet station weightings.

e. Perform calibration simulations with model with proposed operational data and operational model. Repeat process of calibration and hydromet station selection until best model is configured.

(1) Flood runoff calibrations (rain/runoff model).

(a) Decide on calibration procedure (trial/error, optimization).

(b) Select events for calibration (or continuous simulation).

(c) Make calibration simulation.

(d) Make changes and repeat.

(2) Routing calibration (same process as above).

f. Set up procedures for preparing forecast in real time.

(1) Initialization of forecast run.

(2) Estimating missing data.

(3) Estimating ungaged local inflow.

(4) Incorporation of quantitative precipitation forecasts.

(5) Estimating snowmelt.

g. Test applications of forecast model with forecast/ regulation personnel.

h. Document forecast procedures.

E-6. Develop a Plan for the Water Control Data System (WCDS) and the WCDS Master Plan

The development of forecasting procedures will reveal remote gaging needs, whether it be the installation of new stations or the automation of manually reported stations. The WCDS also includes the computer facilities needed for processing data and executing computer models. These developments are documented in the WCDS Master Plan, which is submitted to higher authority for approval.

a. Establish field requirements for operational data.

(1) Determine frequency of reporting, backup requirements.

(2) Automate existing facilities, if needed.

(3) Establish new stations as necessary.

b. Develop plan for field data collection system--land-line, GOES, line-of-sight radio, etc.

(1) Obtain manufacturer’s specifications and costs.

(2) Coordinate with other water resource agencies collecting data in the region. Consult with the Corps of Engineers, Civil Works, Engineering Division, Hydrology and Hydraulics Branch (CECW-EH).

(3) Estimate costs for maintenance--field equipment and receiving site.

(4) Prepare life-cycle cost analysis comparison; select best alternative.

c. Develop plan for WCDS computer processing.

(1) Consult with CECW-EH, HEC, Information Management, and other Corps offices.

(2) Obtain manufacturer’s specifications and costs.

(3) Determine software requirements.

(4) Determine continuity of operations requirements.

(5) Perform life-cycle cost analysis; select best alternative.

d. Write WCDS Master Plan; submit for approval.

e. Establish capital and annual expenditure requirements; budget accordingly (Plant Replacement and Improvement Program (PRIP) and annual funds).

E-7. Develop Flood Control Operation Guidance

The water control plan for flood control operations should include several items to assist regulators and project operators in making regulating decisions. These may require new hydrologic and hydraulic studies, or they may simply require development of existing material for presentation in the water control manual.

a. Regulating outlet and spillway gate opening sequences, limitations.

(1) Consult with hydraulic design engineers; project personnel.

(2) Perform or request special hydraulic analysis as required.

(3) Document procedures with text and diagrams as necessary.

b. Spillway gate regulation procedures.

(1) Review guidance and design documents regarding gate regulation schedules.

(2) Prepare a gate regulation diagram.

(a) Select a design flood for recession volume analysis.

(b) Perform routings.

(c) Plot required outflows versus inflow and storage.

(3) Test diagram by routing with different floods (inflow design flood, historic floods). Adjust as necessary.

(4) Finalize guidance plots; prepare documentation.

c. Miscellaneous guidance curves for flood control operations. There may be need for guidance curves and rules that can be used in the flood control operating plan in lieu of or, in conjunction with, a flood forecasting operation. One application would be as a backup to a forecasting system in cases where communications and power are lost. Examples might be: indices to runoff, given precipitation magnitudes; procedures for changing outflows, given reservoir rate of fill; and rules for operating several dams controlling a single control downstream control point.

(1) Determine need for guidance, considering factors such as:

(a) Remoteness of project; communications and transportation viability.

(b) Accuracy and viability of operational forecasting procedures, models.

(c) Basin runoff response.

(2) Perform hydrologic study using models or manual analysis.

(3) Test guidance on historic floods, design floods.

(4) Prepare plots, narrative text.

d. Examples of flood regulation. Examples of flood control regulation provide a useful form of guidance for water control manuals. These can be plots and/or tabulations, accompanied by explanatory text.

(1) Select floods for possible examples, considering factors such as: magnitude of flood; unusual runoff timing or shape of hydrograph; seasonal considerations; and ability to demonstrate use of guidance procedures.

(2) Perform reservoir routings with historic data, using guidance materials that have been prepared.

(3) Plot hydrographs; prepare narrative material.

e. Emergency instructions to dam tenders when communication is lost. This is a mandatory requirement for dams subject to rapid flood runoff requiring gate operations. It is particularly important for dams in remote areas. Coordination is needed with Dam Safety Plan emergency procedures.

(1) Review operating guidance determined in above paragraphs.

(2) Review staffing, travel conditions, and timing for dam tenders with project personnel. Visit project if necessary.

(3) Prepare procedures for non-guided operation:

(a) Staffing requirements.

(b) Data gathering; project monitoring.

(c) Determination of outflows.

(d) Alert procedures.

E-8. Develop Guidance for Conservation Operation

Although not as critical as flood operation guidance because timing and possible emergency conditions are not as problematic, there may be special procedures which are required for low-flow operations. Examples might be (1) procedures for determining instream flow releases as a function of reservoir status, and (2) municipal and industrial release schedules, etc. This activity might be a part of the Drought Contingency Plan studies, Paragraph E-10.

a. Determine need for guidance.

(1) Review studies used for project formulation and design.

(2) Review historic records; select drought periods for examination.

(3) Consult with affected agencies/parties.

(4) Decide on need for further analysis and need for special guidance.

b. Perform hydrologic study as required, using models or manual procedures. (Refer to Paragraphs F-4 and F-5 in Appendix F for details.)

c. Test guidance on varying hydrologic conditions, considering real-time conditions such as forecasting accuracy or slippage in implementing actions.

d. Prepare plots, narrative description for water control manual. (Refer to Paragraph E-11, below.)

E-9. Development of Guidance for Hydroelectric Operations

The design of the hydro plant for the project and the nature of the hydroelectric system involved will determine how the project is to be operated for power production, so additional hydrologic engineering studies for the water control plan may not be extensive. Possible items: (1) rate-of-change restriction studies, including possible river fluctuation studies; (2) block-loading schedules; (3) plant characteristic charts; and (4) unit operating procedures. Refer to EM 1110-2-1701.

a. Identify need for guidance. (See Paragraph E-8, above.)

b. Perform analysis. (Refer to Paragraphs F-4 and F-5 in Appendix F for details.)

c. Prepare material for Water Control Manual. (Refer to Paragraph E-11, below.)

E-10. Develop Drought Contingency Plan

If the project has a water conservation operating objective, then a Drought Contingency Plan is required in the Water Control Manual. Reference is made to ER 1110-2-1941.

E-11. Prepare Water Control Plan and Manual

The final step in the water control management study is the documentation of the plan of operation in the water control manual. If the plan that has been developed represents a significant change in operation from previous operational policy, then public coordination is required if it hasn't already taken place. Refer to ETL 1110-2-251.

a. Ascertain need for public meeting on Water Control Plan. (Refer to WRDA 90, Sec. 3106.) Prepare materials and hold meeting if required.

b. If meeting is required, prepare briefing material and hold meeting.

(1) Decide on presentations to be made.

(2) Review studies, availability of briefing material.

(3) Prepare new visual aids as necessary.

(4) Hold meeting.

(5) Carry out follow-up actions as necessary.

c. Establish manual content, organization, and work program.

(1) Prepare outline of manual.

(2) Assemble material; identify critical items to be worked on.

(3) Assess human resources requirements, time schedule, funds.

(4) Consider contractor assistance.

(5) Obtain agreement and approval of content and approach. Review with division office.

d. Prepare manual.

(1) Decide on plotting methodology.

(2) Prepare required plots and graphics.

(3) Prepare narrative material.

(4) Conduct first draft review by in-house personnel, division office.

(5) Prepare final manual for approval.